U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

N75-77721

BIOMEDICAL TECHNOLOGY TRANSFER: APPLICATION OF NASA SCIENCE AND TECHNOLOGY ANNUAL REPORT, OCT 1974 SEP. 1975

Stanford University
Palo Alto, CA

BIOMEDICAL TECHNOLOGY TRANSFER

Applications of NASA Science and Technology

Submitted by

STANFORD UNIVERSITY SCHOOL OF MEDICINE
CARDIOLOGY DIVISION

(NASA-CR-145650) BIOMEDICAL TECHNOLOGY TRANSFER: APPLICATION OF NASA SCIENCE AND TECHNOLOGY Annual Report, Oct. 1974 - Sep. 1975 (Stanford Univ., Palo Alto, Calif.) p

N75-77721

Unclas
39641

The Stanford University Biomedical Applications Team

701 Welch Road, Suite 3303

Palo Alto, California 94304

NASA Technology Utilization

Grant No. NASA NGR 05-020-634

ANNUAL REPORT

Oct. 1974 - Sept. 1975

PREFACE

This report summarizes the activities of the NASA Biomedical Application Team program at Stanford University from October 1, 1974, through September 30, 1975. This program is under the direction of Donald C. Harrison, M.D., Chief of the Division of Cardiology within the Stanford University Medical School. This program is supported by NASA contract No. NASA NGR 05-020-634 and its Technical Monitor is Harold Sandler, M.D., Chief of the Biomedical Research Division at the nearby NASA-Ames Research Center.

CONTENTS

INTRODUCTION

The Biomedical Application Team Concept

Congress has directed the National Aeronautics and Space Administration (NASA) to assure the widest possible dissemination of results from space related research and development. In order to insure that NASA developed technology realizes its full potential NASA has developed the Technology Utilization Program. Within this TU Program NASA technology is re-applied and adapted to social, industrial, and medical problems. Four Biomedical Application Teams (BATeams) have been formed specifically to make the technological resources of the aerospace industry available to researchers and practitioners in the field of medicine. These four Biomedical Application Teams have been established at the following institutions:

Stanford University School of Medicine
701 Welch Road
Palo Alto, California 94304

Research Triangle Institute
Post Office Box 12194
Research Triangle Park, North Carolina 27709

Southwest Research Institute
8500 Culebra Road
San Antonio, Texas 78206

University of Wisconsin
1500 Johnson Drive
Madison, Wisconsin 53706

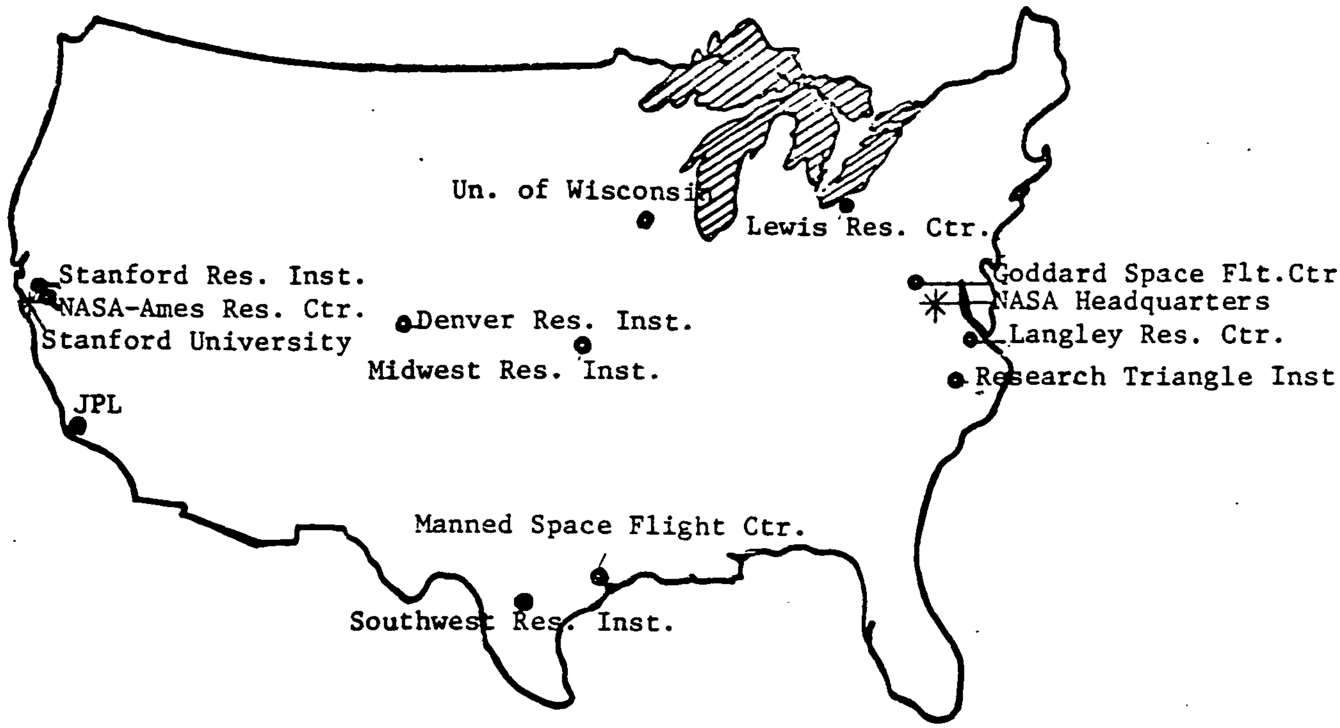
These teams interact with major medical institutions throughout the United States to define specific technological barriers to medical

progress. They then propose solutions to these problems using technology which has been developed for the space program. In general only those problems are accepted which: have no readily available commercial solution, are amenable to a technological approach, and which impede the progress of major medical research and clinical patient care.

Emphasis of the Stanford BATeam

Cardiovascular disorders are by far the leading single cause of death in the United States, frequently causing death or disability during the most productive years of a person's career. Because the Stanford University Cardiology Division is a nationally recognized authority in this field, the major emphasis of the Stanford BATeam has been directed at solving urgent problems in this important area. Past successful transfers of technology in this specialty have included projects in electrocardiography, cardiac catheterization, biomedical electrodes, and uses of ultrasound to obtain images of the heart. Besides these heart disease related areas the Stanford team transfers NASA technology into other areas such as orthopedics and neurosurgery.

As shown on the map on the following page Stanford University is on the West Coast not far from the NASA-Ames Research Center. Thus the activities of the Stanford BATeam have focused on providing the engineering experience and technology developed by NASA to the major medical institutions on the West Coast. Within this geographical area the medical community can be divided into three major categories: 1) medical centers, 2) private or community hospitals, and 3) the private physician's office. Because of limited time and resources available, this team



Location of NASA Field Centers and Application Teams

has endeavored to establish a relationship first with major teaching and research hospitals. These institutions are faced with critical problems affecting a relatively large group of patients. Therefore, the criteria of selecting problems with high potential impact is met. Community hospitals collectively provide care to the largest patient population base and ultimately are the functional units which will most benefit from technological breakthroughs. Since few of these hospitals have the resources of bioengineering and medical instrumentation specialists to provide technological services necessary for solving problems, these institutions have a strong need for NASA engineering expertise.

Past experiences in trying to solve the problems of an individual physician in his private practice have generally not been cost effective.

Usually solving these types of problems leads to the fabrication of a one of a kind device or instrument which is not widely desired by the general medical community even though it may very adequately serve the need of an individual physician. Another serious drawback in an association of this type is the limited time and funds of the problem originator.

For these reasons the Stanford team has directed its technology transfer program to major teaching/research hospitals and large community or private hospitals. Contacts with more than a dozen West Coast hospitals and Schools of Medicine have been made ranging from simple explanations of the service provided by the Biomedical Applications Program to long-term commitment in solving a specific medical engineering problem.

Team Members

The Stanford BATeam is a multi-disciplinary group of scientists, doctors, and engineers who pool their individual talents and experiences to solve problems relevant to both medical research and direct clinical application. The principle members of the team at Stanford University are:

Donald C. Harrison, M.D., Chief of Cardiology and BATeam Director

Harry Miller,Deputy Director

Gene Schmidt, M.D., Bioengineer

Edwin Carlson, M.D., Cardiovascular Research Associate

Richard Popp, M.D., Assistant Professor of Cardiology

Edwin Alderman, M.D., Assistant Professor of Cardiology

Carla Dunham, Program Secretary

Jane Strauss, Conference Coordinator and Special Projects

A.G. Buck, Electrical Engineer, Consultant

Manley Hood and Paul Purser, former NASA Research Scientists, and part-time engineering consultants

These team members at Stanford work in close cooperation with personnel at the nearby field center, the NASA-Ames Research Center, in Mountain View, California. This group includes:

Harold Sandler, M.D., Chief of Biomedical Research Division

Walter Goldenrath, PhD, Asst. Deputy Director of Life Sciences

Charles Kubokawa, Technology Utilization Officer

Robert Lee, Electronic Instrument Development Branch

Salvador Rositano, Electronic Systems Engineering Branch

Ernest McCutcheon, M.D., Biomedical Research Division

Thomas Fryer, Asst. Chief of Electronic Instrument Development Branch

The spirit of cooperation and free exchange of ideas between Stanford and Ames provides this team with a unique breadth and depth of experience necessary for solving biomedical problems.

SUMMARY OF MAJOR ACTIVITIES

The Stanford University Biomedical Application Team's activities for this year fall into two general categories. The first is the category of individual technology transfer projects in which the vast technological know-how which grew out of NASA's goal of providing a safe and comfortable environment for man in outer space is applied to carefully selected medical problems.

Technology Transfer Projects

One of the most widely used biomedical devices is the surface electrode used by physicians when recording an electrocardiogram. Because of a conference and text on biomedical electrodes which was produced by the BATeam two years ago at Stanford many changes have occurred in both design, materials used and fabrication techniques to improve the electrode's signal quality, comfort for the patient and decrease cost of production. As a direct result of BATeam activities the soft flexible electrodes developed by NASA for simulated space flight experiments have been commercialized by a West Coast medical instruments manufacturer.

A portable battery powered echocardioscope originally developed by NASA for use in the space shuttle program has satisfactorily completed clinical tests at the Stanford University Medical Center. The BATeam has published a prospectus to explain the engineering and clinical testing details and market prospects of this instrument to prospective manufacturers. This publication has been sent to such major medical instrument companies as Unirad, Denver, Colorado;

Smith-Kline Instruments, Palo Alto, California; and Picker X-ray Corporation, Cleveland, Ohio. Although no firm commitment has yet been made to manufacture the echocardioscope (as has occurred with the flexible electrodes) this instrument is still under active consideration by potential manufacturers.

A very promising application of NASA transducer and telemetry technology to the treatment of neurosurgical patients has made significant progress during this year. Two different types of NASA developed pressure cells have successfully passed a vigorous testing protocol in the electronics laboratory. These cells are now ready for further rigorous testing in laboratory animals. In addition, the telemetry electronics and power supply systems have been tested and are ready for miniaturization and packaging. Clearance of the protocol for using these pressure cells in patients has been received. Successful completion of clinical trials using patients during this next year will be a necessary step to large scale commercial production.

An advanced system for measuring blood flow using ultrasound has been designed, fabricated and delivered to NASA and Stanford Cardiovascular Researchers. Evaluation of this device on laboratory animals and human subjects is just beginning at the time of this report.

Besides developing and achieving the commercial transfer of NASA technology the Biomedical Application Team provides a unique function in loaning NASA equipment and instruments to biomedical researchers and physicians. During this past year the BATeam has loaned two aerospace helmets to the director of a respiratory intensive care laboratory to assist him in measuring oxygen consumption in debilitated patients.

A similar previous loan of telemetry equipment to cardiovascular researchers has proved very useful in their research and patient evaluations as described in the section, Telemetry During Cardiac Stress.

A device using NASA computer-graphic techniques to assist cardiologists in analyzing X-ray images of the heart has been completed and is being used in cardiac research within the NASA-Ames Research Center but will require further development before being transferred to the Stanford Medical Center for patient applications.

Public Information Activities

Besides individual technology projects requiring the modification, development, institutional transfer, and commercialization of an instrument or other piece of hardware, the Stanford BATeam has also been involved in numerous additional activities to disseminate NASA know-how, experience, and software to the general public.

The most significant milestone in this area this year has been the successful completion of a three-day major conference at Stanford University on Cardiovascular Imaging and Image Processing. This conference focused on the three major areas of angiography, ultrasound, and isotopes as they are used to form images of the cardiovascular system. Since NASA has made unique and significant contributions to the development of technology in each of these three areas, this conference provided an opportunity to make these contributions evident to leaders in the areas of medical equipment manufacturing, biomedical research, and clinical practice. This conference was attended by more than 300 representatives of over 100 business, university, government and medical

institutions. In order to reach an even wider audience, the proceedings of the conference are being published in a textbook entitled Cardiovascular Imaging and Image Processing, Theory and Practice-1975 by the Society of Photo-Optical Instrumentation Engineering and will be released in December, 1975.

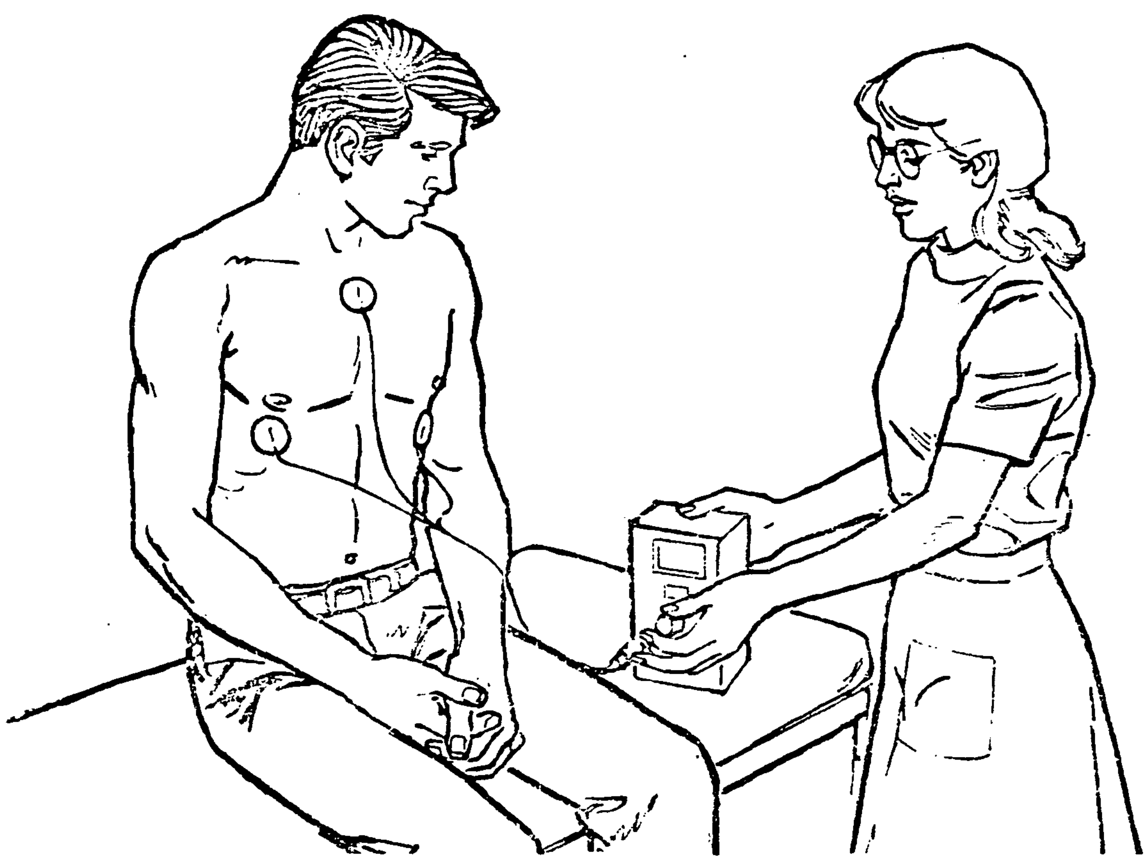
Other important public information activities including journal publications, presentations at Biomedical Symposia, film and television programs, and biomedical instrumentation exhibits were included in the BATeam program for 1974-75.

INDIVIDUAL TECHNOLOGY TRANSFER

PROJECTS

Problem Definition

A biomedical electrode is a device usually made of a highly conductive metal which permits the passage of electrical signals from a patient to a recording instrument. The most wide spread application of electrodes is in recording the electrical activity of the heart, the electrocardiogram, frequently abbreviated ECG. While the electrode may seem at first to be a rather simple device, it has provided difficult technological problems particularly in the area of long-term monitoring of patients. While millions of dollars have been spent by industry to develop amplification and filtering systems to improve electrical signals, inadequate attention has been focused on the electrode itself which picks up the original signal from the patient.



Electrodes being used for long term ambulatory monitoring

Background

NASA has had vast experience in the development and use of high quality electrodes to monitor the physiological activity of astronauts during space flights. In order the disseminate NASA expertise in obtaining dependable long-term electrical signals using biomedical electrodes, the Stanford Biomedical Applications Team held an International Conference at Stanford University in the fall of 1973, entitled Biomedical Electrode Technology-Theory and Practice.

Impact

As a direct result of ideas exchanged and personal contacts made during this electrode conference the In Vivo Metric Systems Company of Redwood Valley, California, has introduced a new line of flexible skin electrodes which are described in their product bulletin shown on the last page of this section. Hayes Products, Inc., Seattle, Wasington, has worked with the Stanford BATeam to develop an improved design for this type of electrode. Most recently, the Life Technical Instruments Company, Houston, Texas, has also expressed an interest in manufacturing a similar electrode.

Besides the immediate value of encouraging companies to manufacture improved electrodes, the publication of the text, Biomedical Electrode Technology-Theory and Practice is proving to be a valuable resource for university and industrial scientists who are doing research to improve the performance of electrodes. To cite a specific example, the University of Wisconsin is submitting a report for publication which is in response to one of the major problems raised during discussion at the 1973 NASA-Stanford Biomedical Electrode Technology Conference. Entitled Motion

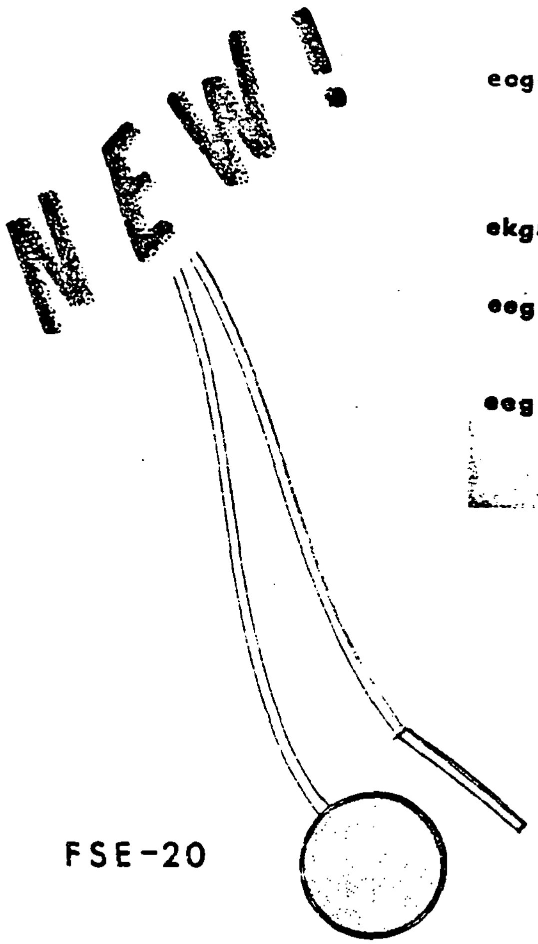
Artifact, Cause and Cure, this article by members of the Department of Electrical and Computer Engineering makes repeated reference to this NASA sponsored reference text. Publications of this book have doubled in the last six months and reached a total of 1,325 in August, 1975.

Plans are to continue to disseminate information on NASA experience with biomedical electrodes and related technology, to encourage more manufacturers to improve their electrodes, and finally to assist with on-going research to improve both the understanding of electrode principles and improvements in their design and use.

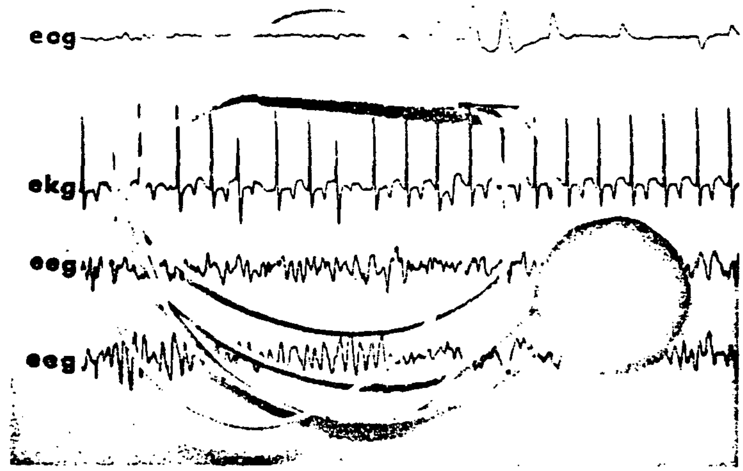
The following page is a copy of the product bulletin from a company which presently manufacturers an electrode patterned after the NASA flexible electrodes.

IN VIVO METRIC SYSTEMS
P.O BOX 217 • REDWOOD VALLEY • CALIFORNIA 95470
TELEPHONE (707) 485-7616

FLEXIBLE SKIN ELECTRODES



FSE-20



introducing . . . .

F S E - 2 0

A flexible biopotential skin electrode developed by N A S A technology

ADVANTAGES

* Conforms to body surface during motion.
* Allows long term monitoring of all skin biopotentials with comfort to the patient.
* INEXPENSIVE

PORTABLE ECHOCARDIOSCOPE

Problem Definition

New techniques and instruments are needed by the physician to rapidly and painlessly obtain detailed pictures of the heart. One type of instrument for solving this problem is called an echocardioscope. It uses high frequency sound bounced off of the patient's heart to form a dynamic picture. An echocardioscope uses sound in much the same way that sonar is used to locate objects under water.

NASA Technology

NASA engineers are developing new types of echocardioscopes for use by astronauts on Space Shuttle. One of these instruments is a portable battery-powered device that was developed in cooperation with cardiologists at Stanford University Medical Center.

Progress During the Past Year

Clinical validation of this instrument has been completed involving a total series of 100 patients at Stanford University Medical Center. These patient tests included a group of 20 acutely ill infants in the newborn nursery who were suspected of having congenital heart disease. One such infant depicted in the next figure is undergoing an echocardioscope examination by a pediatric cardiologist. Tests such as this have shown this instrument to be a safe and effective diagnostic tool which

Acutely Ill Infant Undergoing Ultrasound Exam to Detect Heart Disease.

provides heart images equal in quality to the best commercially available echocardioscopes.

Besides completing the medical validation, a marketing prospectus has been published by the Stanford BATeam to describe this instrument in engineering terms and explain its unique advantages over existing similar instruments. In essence these are:

1. Easy portability
2. Rechargeable battery operation
3. Anticipated lower production costs due to modular construction

Anticipating that this device would be useful to the practicing cardiologist both in Intensive Care Units, Neonatal Nurseries, Operating Rooms, and as a personalized instrument which can be easily carried wherever the doctor is seeing patients, the BATeam is currently seeking large scale commercialization of this new instrument.

Plans

At the present time major medical instrumentation manufacturers are being contacted in an effort to get this instrument commercialized for wide-spread distribution and use. The following are examples of correspondence pursuant to this goal.

PICKER CORPORATION
NUCLEAR & ULTRASOUND
12 CLINTONVILLE ROAD
NORTHFORD, CONNECTICUT 06472

September 3, 1975

Gene Schmidt, M.D.
Biomedical Application Team
Stanford University School of Medicine
701 Welch Road, Suite 3303
Palo Alto, CA 94304

Dear Dr. Schmidt:

It was very nice talking to you today regarding the portable Ultrasonoscope. At the present time it is our feeling that the Market for this type of instrument is not large enough to support the expenditure required to manufacture and market the system. As I mentioned to you on the phone, I have talked to Dr. Popp who believes that the quality of the Echocardiography tracings were good, but is also not too sure where the market may lie for this instrument.

At the present time I see two possible uses: One being in the operating room where leakage circuits and high voltage can present a significant safety problem and the other being for the Internist or Cardiologist who work at several hospitals and would want to bring the instrument with him. We are taking steps to try to determine how large this market might be, however, it is our feeling that it is relatively small.

I certainly appreciate your giving Picker the first opportunity to look at this instrument and if our Market Research indicates that the market is larger than our initial estimates, we may desire to pursue this further. In the meantime, however, I certainly have no objections to your taking this to other Ultrasound Manufacturers for their consideration.

Sincerely,

Lewis H. Rosenblum

Lewis H. Rosenblum
Product Manager - Ultrasound

LHR:mlb

PICKER

SKI Smith Kline Instruments, Inc.
880 West Maude Ave • Sunnyvale, CA 94086 • (408) 732-6000
A Subsidiary of SmithKline Corporation

September 18, 1975

Gene Schmidt, M.D.
Biomedical Technology Transfer
Cardiology Division
Stanford University School of Medicine
701 Welch Road, Suite 3303
Palo Alto, California 94304

Dear Dr. Schmidt:

Thank you very much for your letter of September 4 discussing our interest in the battery powered ultrasonoscope designed for cardiology by NASA Ames Research. I saw the unit in its early stages and have not had a chance to re-evaluate it.

Quite frankly, we are currently making a concerted marketing effort with our present instrument into the doctor's office. However, we recognize the need for a smaller more useful instrument. Therefore, we would welcome the opportunity of discussing this possibility with you and your colleagues at your convenience. I will be out of town from September 20 to October 3. If you wish initial discussions during my absence, you can do this by calling Mr. Ed Culotta who is Vice President in charge of marketing.

Thank you for considering us.

Sincerely,

SMITH KLINE INSTRUMENTS, INC.
SmithKline Corporation

Thomas G. Davis, M.D.
President

:dme

TWX (910) 373-1245 SKI PLA

cc: E. Culotta, J. Sweetman

Problem Definition

Intracranial pressure is simply the pressure inside of a person's skull and can increase to dangerous levels in patients with brain injury. A rise in intracranial pressure can result from external trauma (such as in the case of accidents) or internal trauma (due to strokes, tumors, and hydrocephalus). Knowing the value of this pressure at any given time is extremely important to physicians and particularly to neurosurgeons in order to decide on the correct course of medical or surgical therapy for the patient.

Background

The goal of this project is the long-term continuous measurement of intracranial pressure in patients with brain injury. At present, the neurosurgeon attending a patient with rising intracranial pressure relies on fairly insensitive and unreliable clinical signs to assess this important parameter. Unfortunately, these signs frequently do not appear until significant brain damage has already occurred.

Relevant NASA Technology

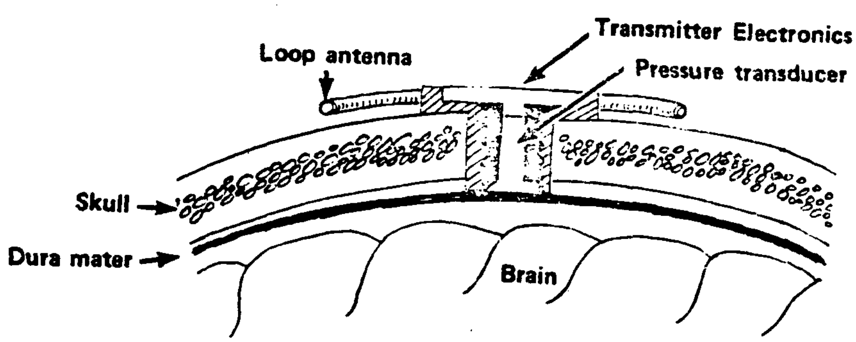
The major progress during this past year has been in the application of NASA transducer or pressure cell technology and telemetry to this problem. Two prototype capacitance transducers originally developed by NASA for use in aircraft wind tunnel testing, have been re-designed and fabricated for medical application.

NASA Pressure Cell and Transmitter Electronics (right) Miniaturized And Packaged (at left) For Use in Patient Monitoring.

In order to make these pressure cells compatible with biological fluids in humans, the outer casing is made of titanium. NASA engineers have also successfully "bread-boarded" a power supply and read out system which eliminates both the need for implanting batteries under the skin and eliminates the need for wires passing through the scalp which could lead to a serious infection or meningitis. Also during the past year major emphasis has been placed on thoroughly bench testing a silicon chip pressure sensor which has shown remarkable base-line stability for time periods of one month.

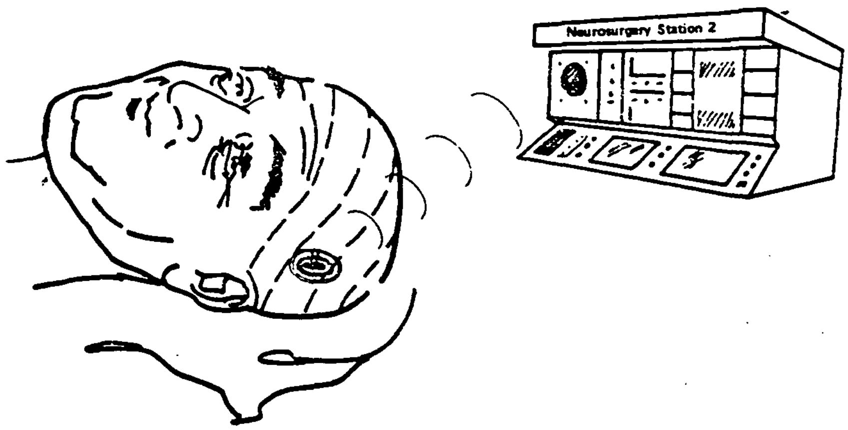
Approach

The procedure for long-term monitoring of a patient's intracranial pressure begins with the drilling of a small burr hole in the patient's skull so that a tiny pressure cell can be inserted with it's pressure sensitive part resting against one of the coverings of the brain, the dura mater (see figure). This pressure cell also contains the necessary microelectronics to act as a radio transmitter or telemetry system. Just prior to completing this relatively minor surgical procedure a loop antenna is placed outside the skull just beneath the scalp which is then sutured closed. This loop antenna serves two functions. It acts as both a transmitting antenna and as a pathway by which power can be inductively trans-



Cross-sectional Diagram of Implanted Intracranial Pressure System.

mitted through the skin to power the pressure cell and transmitter. The pressure signal from the transmitter is received at the nurses station in the intensive care unit where a permanent continuous record is made (see figure).



Stroke Victim Having Intracranial Pressure Monitored Using NASA Pressure Transducer

Impact

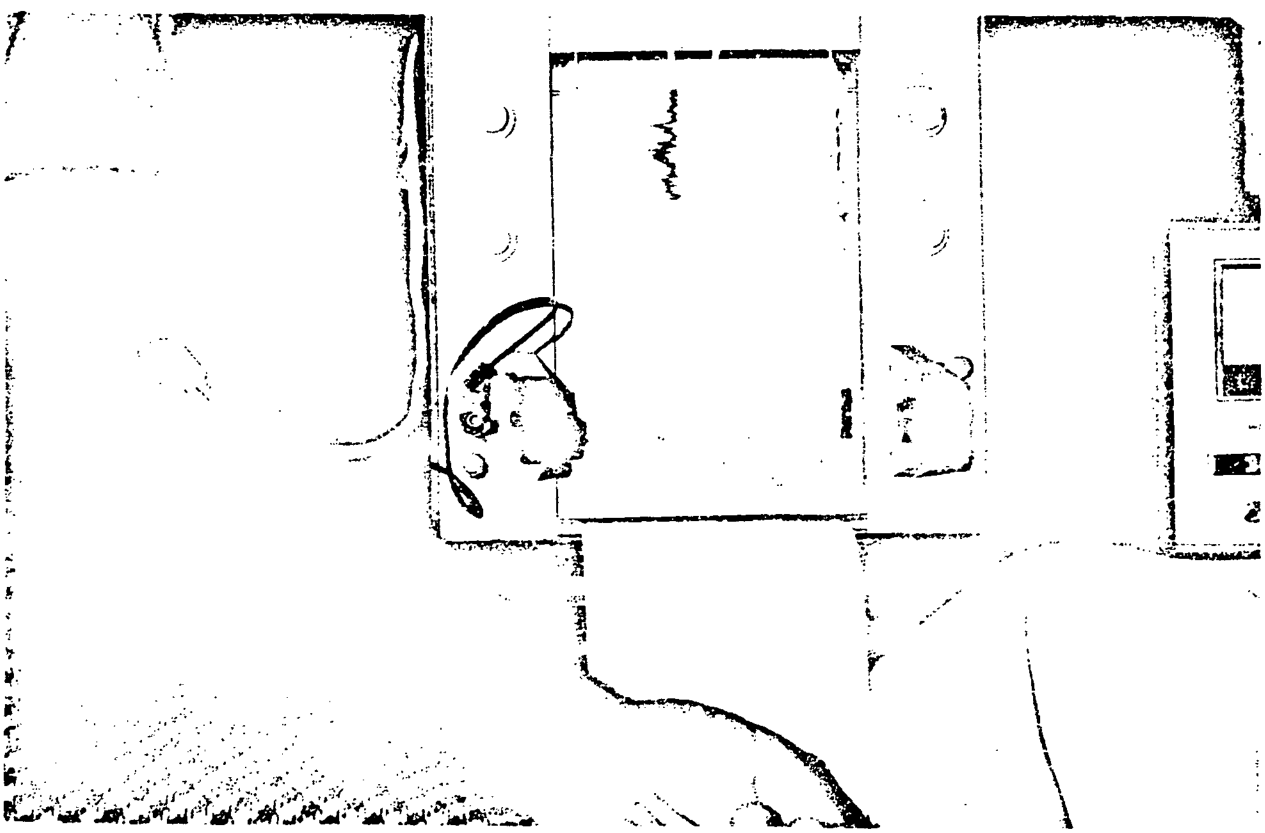
More than 50,000 patients each year are treated for rising intracranial pressure by neurosurgeons. These include both young patients who have sustained significant head injuries in automobile accidents and older patients who have had a stroke or brain tumor. There is also a large number of children with hydrocephalus, a condition in which there is an excessive accumulation of fluid inside the brain, for which a long-term continuous monitoring technique such as this would be extremely valuable.

Plans

Having identified, modified and fabricated the relevant NASA technology the doctors and engineers involved in this project are now ready to conduct full scale animal tests of this equipment. Pending successful completion of these animal tests, this group will proceed with clinical trials in patients in the spring of 1976.

Problem Definition

The goal of this project is to develop, clinically test and implement new instruments for the non-invasive determination of blood flow velocity. The instrument used for measuring the speed at which blood is circulating is based on the Doppler principle. The Doppler shift is simply the change in frequency or pitch that occurs when sound is reflected from a moving object. A familiar example of this phenomenon is the increased pitch of noises coming from an approaching train compared to the much lower pitch of sounds from a train that is receding from an observer. In the human body high frequency sound can be safely used in a similar way to measure the speed at which blood circulates.



NASA Doppler Flow Instrument Recording Wave Form From a Major Artery.

Significance

An instrument for accurately measuring the circulatory speed of blood in a vessel would be useful for evaluating the state of health or disease of arteries and veins. Such an instrument could be put to many uses including locating and quantifying the degree of obstruction in vessels caused by atherosclerosis or hardening of the arteries. Another use would be in assessing the flow of blood through artificial by-pass grafts. Still another use is the detection of blood clots in the deep veins of the legs.

Relevant NASA Technology

During this past year cardiovascular researchers and engineers at NASA have been developing a two channel continuous wave ultrasound instrument based on the Doppler principle described above. The specifications, design, and fabrication of this instrument have recently been completed. This device is unique in relation to other existing Doppler flow meters in two respects:

1. Its sound emitting and detecting crystals are oriented so that the velocity of blood flow deep within living tissues can be measured instead of being limited to only vessels lying close to the surface.
2. It has the capability for performing "frequency spectrum analysis" which will convey detailed information regarding the entire range of blood flow velocity existing in normal subjects versus patients with arterial or venous disease.

Plans

Now that this instrument has been delivered from the L & M Manufacturing Company it is ready for evaluation in both laboratory animals and human volunteers. Plans are to proceed with these studies on a limited scale before larger clinical applications are undertaken.

Problem Definition

During the analysis of X-ray motion pictures taken of the heart, the calculation of various anatomic quantities is based on measurements which are at present made by hand. Because the calculations based on these measurements lead the heart specialist to a specific diagnosis and recommendation for either medical treatment or surgery, the accuracy and repeatability of these manual measurements is important. To reduce the human error involved in this process, on-line computerized methods for rapidly detecting and analyzing the X-ray image of the heart are being developed.

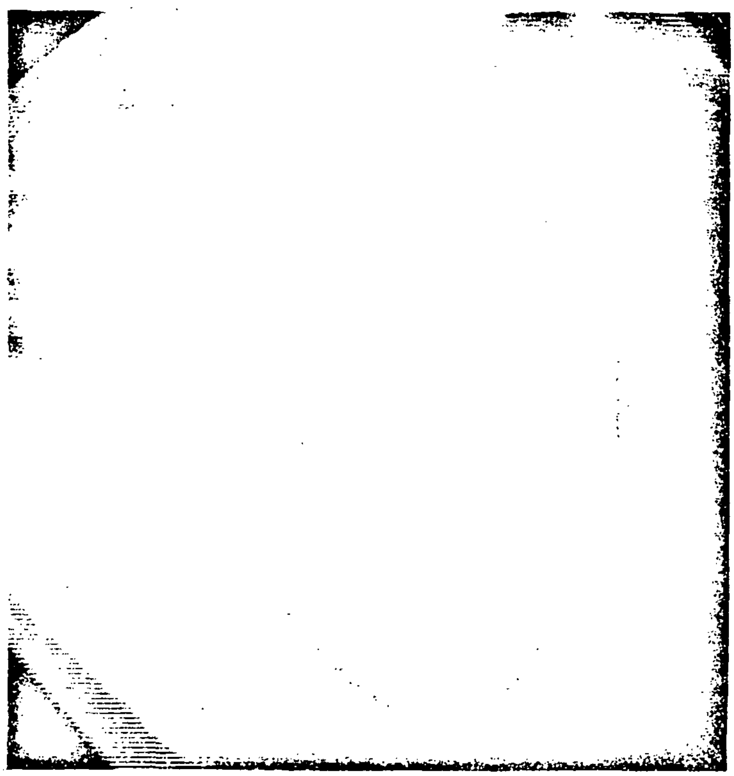
Relevant NASA Expertise

Analog and digital computer-graphic methods have been developed by NASA for analysis of X-ray images of the heart taken during stress testing before, during and after simulated space flights.

Approach

The Stanford BATeam has coordinated an effort between Stanford cardiologists and NASA engineers to continue the development of computer graphic techniques applied to the problem of rapidly and accurately evaluating X-ray motion pictures of the heart. A significant portion of the anatomy of the heart that is revealed during X-ray studies is the outline or contour of the left ventricle, the main pumping chamber of the heart. The size, shape, and movement of the walls of the heart (or contractility) are directly related to the ability of the heart to function

as an efficient pump. To make the outline or contour of the heart visible to X-rays a special dye is first injected into the ventricle or pumping chamber. As this dye is pumped out of the heart, X-ray motion pictures can be made. These are recorded both by video and film techniques. An image of the ventricle can be displayed on a video monitor as shown in the figure below. With the use of a computer this image is scanned and a single white line contour or outline is rapidly and automatically drawn (see figure).



Computer Drawn Ventricular Outline of X-ray Image of Human Heart.

The coordinates of this outline are stored in the computer's memory. These coordinates are used to make a printed tracing of the image and to perform a large number of calculations which tell the heart specialist such important information as the size of the heart, the amount of blood ejected with each beat, and the amount of contraction taking place in

different portions of the heart. This working system has been shown to be accurate within two percent when predicting the volume of plastic casts of hearts for which the exact volume is known.

Plans

A team from Stanford consisting of cardiologists, a computer programmer, a computer hardware engineer, and a biomedical engineer have reviewed and evaluated this automated ventricular contour detection system. At present, it is not ready for direct transfer to the hospital for use in patients and will continue to be further developed at the NASA field center and used in cardiac research to expedite the analysis of X-ray motion pictures of the hearts of laboratory animals.

OXYGEN CONSUMPTION IN DISABLED PATIENTS

Problem Definition

Physicians at the Albert Einstein College of Medicine in New York have requested assistance in determining the oxygen consumption of disabled patients. Many of the patients cared for in the pulmonary clinical laboratory within the rehabilitation department are disabled because of strokes, amputations, neuromuscular defects, and diminished respiratory reserve. Frequently these patients have no teeth and cannot bite down on the standard mouth pieces used for collecting expired air during routine oxygen consumption determination. In addition, because of lack of facial symmetry and inability of the patient to fully cooperate because of his debilitated state, standard face masks which cover only the nose and mouth do not achieve an adequate air-tight seal.

Significance

Solution of this problem would facilitate determining oxygen consumption in patients with these types of disabilities and allow evaluation of both standard and new respiratory assist devices. In addition, the benefit derived from physical therapy and respiratory exercises could be evaluated.

NASA Technology

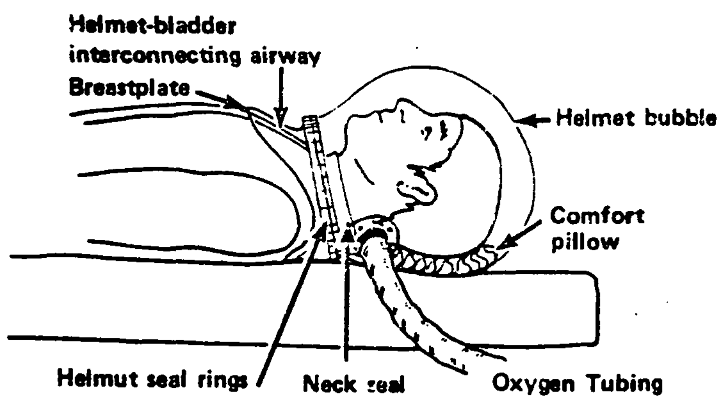
A possible solution to this problem is the full face oxygen mask or helmet used by jet pilots. Both a standard Navy face mask and a bubble configuration helmet have been loaned to the physician who submitted this problem.

Approach

At present these face masks are being modified to provide an exhaust port for exhaled air. The exhaled air will be trapped in a collection bag and the oxygen content will be measured to determine the patient's oxygen consumption.

Plans

Once these minor modifications have been made the physician will be able to evaluate these full face aerospace masks on patients in the clinical pulmonary laboratory.



NASA Bubble Helmet Applied to Measuring Oxygen Consumption of Patients.

TELEMETRY DURING CARDIAC STRESS

Problem Description

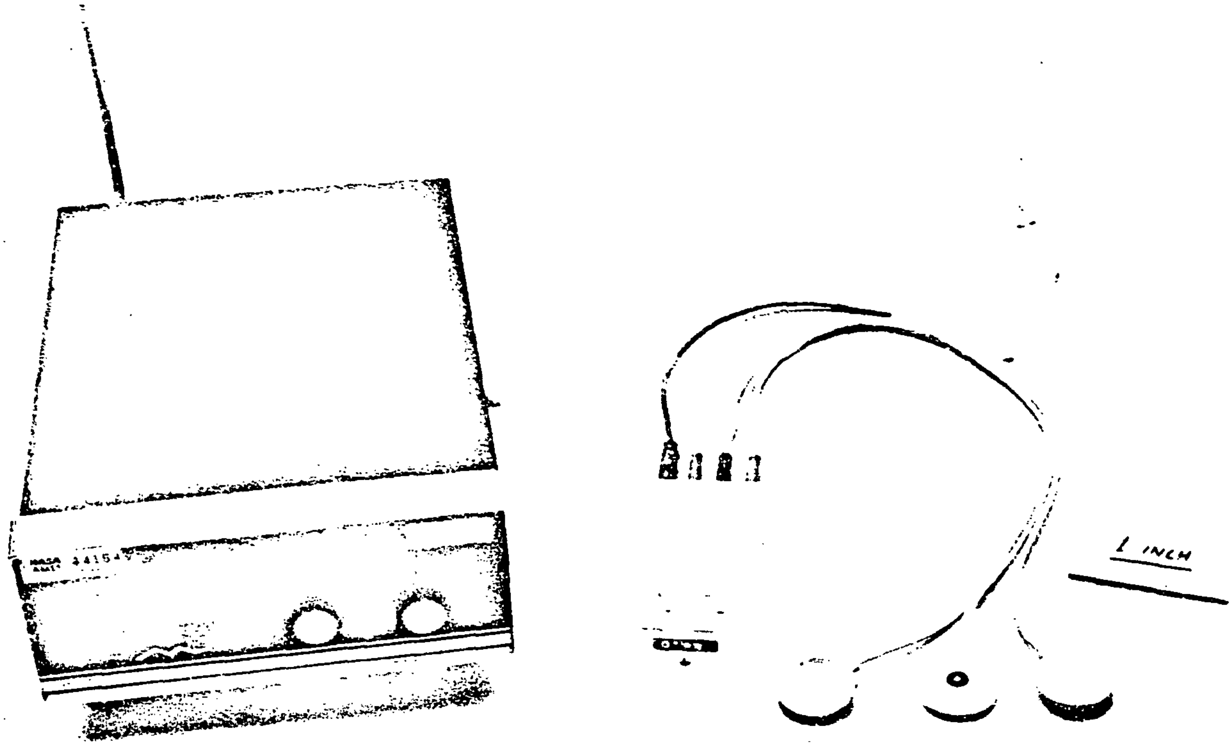
Investigators at the Cedars-Sinai Hospital in Pasadena, California, need to monitor the electrocardiogram of both patients recovering from heart surgery and laboratory animals used in the investigation of new drugs for controlling certain heart conditions. Traditional methods have required that the subject under study be hooked up to a recording instrument via a long cable of wires. Such wires were the source of signal noise and were subject to damage by an uncooperative animal. In addition, patients felt that their freedom of movement was hindered by being attached to a trailing cable during stress testing and rehabilitative exercise programs.

NASA Technology

The Stanford BATeam has loaned these investigators a single channel biotelemetry system like the one depicted below. This FM transmitter/receiver telemetry unit was developed as a part of the NASA bioinstrumentation used for monitoring astronauts during orbital missions.

Approach

During the past year approximately 20 dogs were investigated using this telemetry system. Each dog had a condition called "complete heart block" induced by a surgical procedure. This was done to simulate a diseased state which frequently occurs in the human heart. Electrodes placed over the animal's chest detected the signals from his heart (ECG) and conveyed them to the transmitter strapped to his back. As the animal was exercised, any irregularities in his heart rate were received and



NASA Receiver (left) and Transmitter With Electrodes (right).

displayed. Experimental drugs for the treatment of these irregularities could then be given and their efficacy determined.

The other thrust of this work was to observe the electrocardiogram of patients recovering from coronary artery by-pass surgery, a surgical method for providing a new blood supply to deficient areas of the heart. It is often a difficult challenge to rehabilitate these individuals and prevent them from becoming cardiac invalids. These patients are now able to participate in a reconditioning problem and are monitored during stress tests without being encumbered physically and psychologically by a trailing bundle of wires.

Plans

This group of investigators is planning to publish the results of their work soon in the medical journal Circulation. In this publication they intend to acknowledge the technical support provided by NASA through the loan of this telemetry equipment. A similar project to apply a multi-channel telemetry unit to a group of alcoholic patients during rehabilitation at the Sepulveda Veterans Administration Hospital is in the planning stages.

ADDITIONAL ACTIVITIES

ADDITIONAL ACTIVITIES

Biomedical Electrode Conference Impact Survey

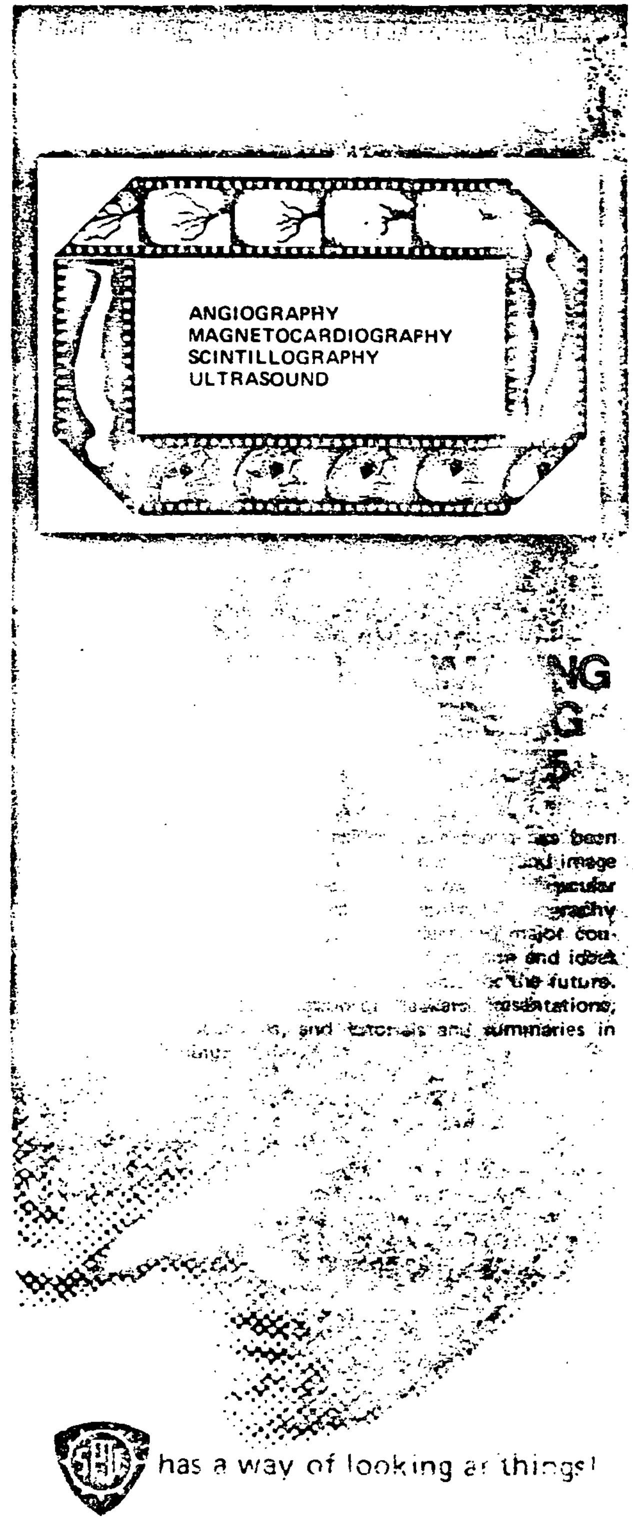
In September, 1973, the Stanford University Biomedical Application Team and NASA sponsored a two day conference held at Stanford University, presenting the major recent advances in biomedical electrode technology. Both theoretical and practical aspects of this subject were covered by experts in material sciences, physics and engineering, research and clinical applications, and space flight applications.

In order to document the positive impact that can result from conferences such as this the Stanford BATeam conducted a survey of conference attendees, including representatives of business and industry, during the past year. The major impact of this International Biomedical Electrode Conference has been in the following areas:

1. Informing conference participants of the latest advances in electrode technology originated both by NASA, the medical and academic communities, and private industry;
2. Exposing present gaps in the understanding of electrode function with a view towards stimulating and guiding on-going research;
3. Publication of a new reference text entitled Biomedical Electrode Technology (Theory and Practice) edited by the Stanford BATeam and published by Academic Press, Inc.
4. Initiating improvements in the type of materials used and designs employed by manufacturers of electrodes.

5. Encouraging medical device manufacturers to enter the market with new types of electrodes which were discussed at the conference.

Encouraged by the positive findings of this survey and the increasing popularity of the reference text, Biomedical Electrode Technology (Theory and Practice), a subsequent major biomedical conference sponsored by NASA and the Stanford University Medical School Division of Cardiology was held in July of this year.



The Cardiovascular Imaging and Image Processing Conference

The Biomedical Applications Team held a major conference July 10-12, 1975, at Stanford University entitled Cardiovascular Imaging and Image Processing: Ultrasound, Angiography, and Isotopes.

NASA's Role

NASA technology developed for processing photographs from orbiting satellites and from deep space probes has been successfully applied to improving images of the beating heart which have been recorded using

X-ray motion picture and sonar techniques. The NASA-Ames Research Center, the Stanford University Cardiology Division, and the Jet Propulsion Laboratories have been applying NASA developed technology to the areas of x-ray and ultrasound instruments. While Stanford has been a leader in the field of clinical applications of high frequency sound to imaging the heart, the Jet Propulsion Laboratory in Pasadena, California, has had extensive experience with image processing, enhancement, and display techniques.

Because much of this work relating to cardiovascular imaging and image processing has not received wide-spread attention, this conference provided an ideal forum for its presentation and dissemination. This three day international conference brought together more than 300 representatives of business, industry, medicine, government, and academia. The tutorials, speakers presentations, discussions, and summaries which comprised this conference are presently being edited into a reference volume which will be published by the Society of Photo-Optical Instrumentation Engineers. It is expected that this new publication will be available for distribution December, 1975.

PUBLIC INFORMATION ACTIVITIES

One of the essential functions of biomedical application teams is to inform the scientific community and general public of NASA technological developments and capabilities which can be applied to solving medical problems. The scientific communities can be reached through presentations at major medical and engineering symposia and through publications of articles in scientific journals and reference texts. On the other hand, the general public is most readily informed through newspaper articles, radio and TV programming, and public exhibitions showing examples of NASA developed instruments which have potential medical applications. During this past year the team at Stanford has employed a multi-media approach to disseminate information concerning existing and potential uses for NASA developed equipment and experience that can be transferred to the medical field. The activities which follow were conducted by members of the Stanford Biomedical Application Team during this past year for the purpose of informing the general public, the medical and scientific communities, and manufacturers and businessmen of both completed transfers of aerospace technology to medicine and potentially useful systems and devices which could lead to improved medical diagnostic and treatment capabilities.

Publications and Presentations

At the tenth annual meeting of the Association for the Advancement of Medical Instrumentation (AAMI) a paper was presented entitled "Doppler Measurement of Mitral Flow at Rest and During Lower Body Negative

Pressure (LBNP)", by E. Carlson, W. Freund, H. Sandler, and J. Meindl. This presentation described two techniques which are being explored by the Stanford BATeam as aids in diagnosing cardiovascular disease. The first technique is the use of high frequency sound to measure the flow characteristics of circulating blood and the second is the use of lower body neagtive pressure in stress testing heart patients.

Three presentations were made at various other medical and engineering symposia describing the portable battery-power echocardioscope described earlier in this report. Essentially this is an instrument for obtaining images of the beating heart totally non-invasively by means of a high frequency sound sonar technique. The first presentation of this device was made at the 12th Annual Rocky Mountain Bioengineering Symposium held in Denver, Colorado, by H. Miller. The paper titled "The Ames 2-E, A New Development in Cardiac Ultrasound" by G. Schmidt and H. Miller has been published in Biomedical Sciences Instrumentation, Vol. 11, edited by K.C. Rock, University of Colorado. A second presentation of this instrument was made at Stanford University, Palo Alto, California, at the Cardiovascular Imaging and Image Processing Conference. A paper entitled, "The Stanford-Ames Portable Echocardioscope: A Case Study in Technology Transfer" was authored and presented by G. Schmidt as part of the session on commercialization of new technology.

Also, this instrument was presented at the annual Western Electronics Show and Convention, WESCON, 1975, in San Francisco. The "Development of a Portable Cardiac Ultrasonoscope" by G. Schmidt and H. Miller has been published in the proceedings of that convention in Vol. 20, Needs and

Trends in Medical Electronics-1975.

Another major conference in which members of the BATeam participated was the 28th Annual Conference on Engineering in Medicine and Biology (ACEMB) held in New Orleans, Louisiana. Pressure transducers originally developed by NASA are described in the article "Accurate Measurement of Intracranial Cerebral Spinal Fluid Pressure by an Epidural-Technique," by A. Ream, G. Silverberg, J. Rolfe, B. Brown, and J. Halpren. This paper has been published in Vol. 17 of the Proceedings of the 28th Annual Conference on Engineering in Medicine and Biology.

Television Programming

In August, 2975, Dr. Harold Sandler, Technical Monitor for the Stanford Biomedical Application Team, and Salvador Rositano, Bioinstrumentation Engineer, were interviewed on the half-hour Bay Area TV program, "The Issue Is". Benefits to the medical field of NASA's Technology Utilization Program were discussed with particular emphasis on the area of biomedical instrumentation. Several examples of devices used to monitor orbiting astronauts which are being re-applied to medical/clinical applications and research were discussed.

Public Exhibit

In September a multi-modular bioinstrumentation exhibit was put on display at Foothill College, located in a peninsula community 30 miles south of San Francisco. This display included working models of the protable battery-powered echocardioscope, A Doppler flow meter, an infrared detector, and an ECG telemetry device.

The public was encouraged to use these instruments to monitor their own physiological functions and movies made of this exhibit were included in the above mentioned television program shown locally on Channel 11.

Space-Age Medical Machines On Display

By CATHY CASTILLO
Staff Writer

LOS ALTOS HILLS — Heart action can be measured at the touch of a fingertip and blood flow can be translated into sound by some of the special equipment NASA Ames Research Center will have on display at Foothill College this weekend.

"These are all non-invasive devices," said Sal Rositano, one of two bio-engineers who will be on hand at the college's Electronics Museum through Sunday demonstrating the devices.

They were devised by scientists to monitor the health of men in space but today the basic principeles are being used on earth to study the heartbeat of an unborn child, to look for hidden tumors or to help determine the extent of burns.

"The space program is like the early days of air travel," said Rositano. "In the early days stewardesses were nurses because people weren't quite sure what kind of problems they would run into flying.

"So far we've sent only young men in top physical condition into space but with the space shuttle we will be letting more people with all kinds of medical backgrounds take part."

" Most of our senior scientists are older. We want to know if we can send someone with a history of diabetes or a heart condition."

From 1 to 5 p.m. today and Sunday the public will be able to try out the machines to hear their own blood flowing through arteries, to measure their body heat and record their heart action.

None of the devices require undressing or exposure to potentially harmful substances, such as X-rays.

The Doppler blood flowmeter measures blood action on the same principal as a sailor using sonar to find a ship in a fog. Doctors use the same principal to find obstructions in arteries or to monitor the heartbeat of an unborn child.

Rositano and Jack Connolly, the researchers who will be on hand, have displayed the machines a few other times and hope to be able to see them displayed in Washington next year for the opening of the Air and Space Museum at the Smithsonian Institution.

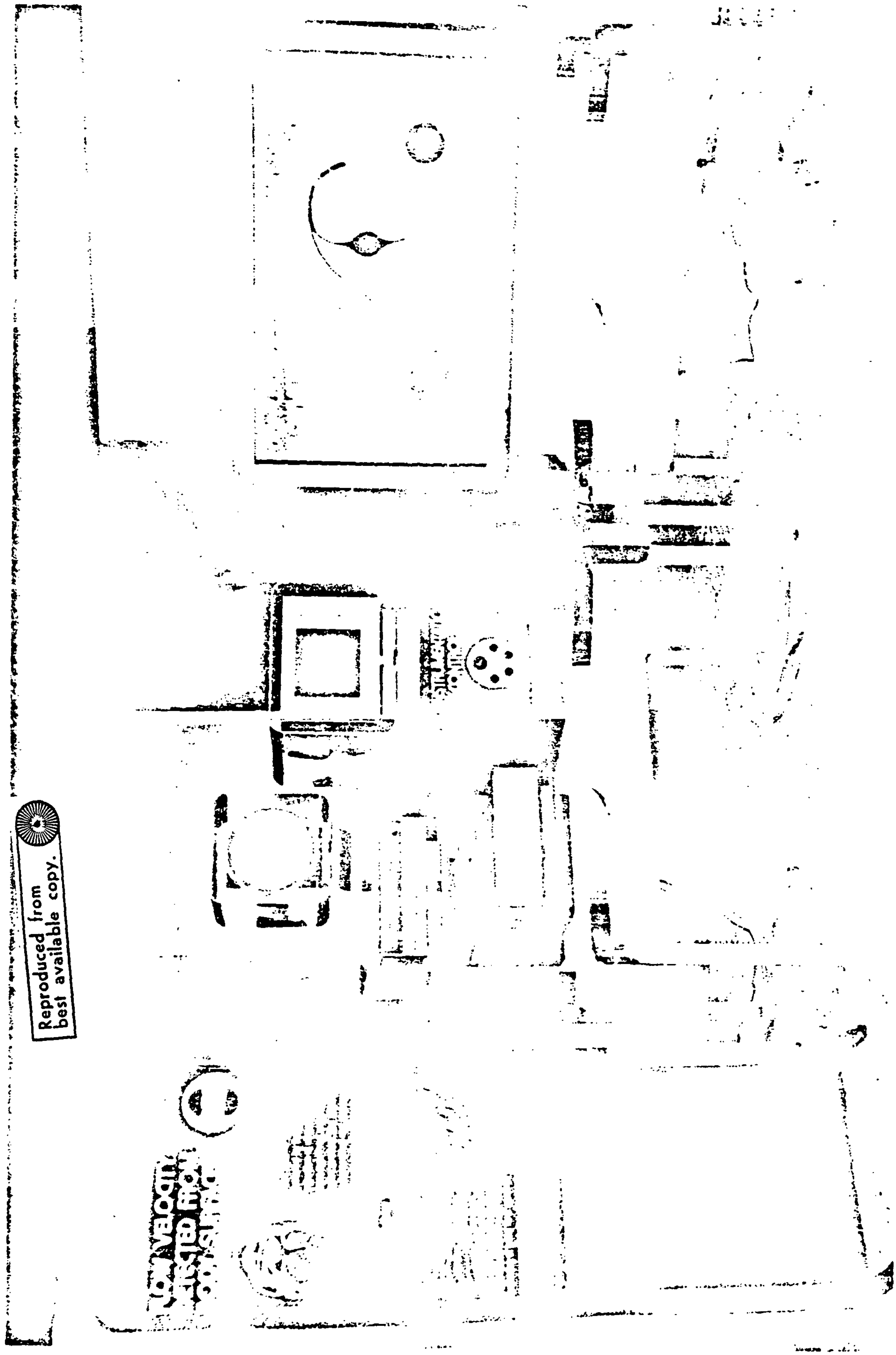
Rositano believes scientists and private industry should make an extra effort to explain what they are doing to the general public.

"The greatest thing is to have some kids come through and see their faces light up when they find we're doing something they really understand," he said.

The displays may cause some youngsters to enter fields of science they never would have thought of, Rositano said.

And he would like to see more public education like the current NASA-Ames exhibit.

"Sometimes we are criticized for blowing our own horn with these things, but they serve a real public education function."



NASA Biomedical Instrumentation Exhibit at Foothill College.